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# SOME NOTES ON THE FACTORS CONTROLLING THE RATE OF REGENERATION IN TAD- POLES OF *RANA CLAMATA*—DAUDIN.<sup>1</sup>

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During the fall of 1907 some experiments were undertaken at the Zoölogical Laboratory of Indiana University at Bloomington, upon tadpoles of *Rana clamata* as a study of factors controlling the rate of regeneration. The results of this work are given in part in this preliminary report.

Tadpoles varying in body length from 35 to 40 mm. were arranged in series so that comparisons showing the influence of age, level of injury and location of injury (*i. e.*, whether the operation was in old or regenerating tissue) upon the rate of regeneration and the relation of first to second regeneration were made possible.

1. *Age*. — Tadpoles, 10 mm. whose tails had been removed. were used in this comparison. They were of four different ages with respect to the time of operation. The first set was operated upon on the date  $X$ , another on  $X + 10$  days, a third on  $X + 12$  days and the last on  $X + 22$  days. Those injured on  $X$  had the highest rate of regeneration and those on  $X + 22$  the lowest. The other two sets were both lower than the first. These differences in rate were not due to laboratory conditions as that point had been eliminated. As all other factors were controlled it is quite evident that the rate of regeneration of the tadpole tail decreases as the animal grows older. The averages are given here: Those of the date  $X$  regenerated at a rate of .39 of a millimeter per day;  $X + 10$  days, .35;  $X + 22$ , .26. These figures show a decided decrease in the rate with an increase in age,  $33\frac{1}{3}$  per cent. of the rate being lost during the 22 days between the date of the first and last operations.

2. *First and Second Regeneration*. — The data collected are not at all conclusive for the relation of the rate of first regener-

<sup>1</sup>Contribution from Zoöl. Lab. of Indiana University, No. 94.

ation to that of second regeneration, age and level of injury being the same. Two comparisons were made and in the averages second regeneration is slightly less than first in one case and equal to it in the other. First regeneration .35, second .33; first .26, second .26. It is to be concluded from the averages that second regeneration differs very little from the first.

3. *Location of Injury.* — The effect of location was obtained from a set of tadpoles that had had 10 mm. of tail removed. After they had regenerated about 5 mm. they were again operated upon — one half 3 mm. caudad of first cut and the other half 3 mm. cephalad of the first cut. The first half gave a regeneration from tissue but recently laid down, the second a regeneration from old tissue in a tadpole that had just been regenerating from a level nearer the tip of the tail. Neither half varied greatly from the control but both were below it. The averages for those cut caudad of first injury are .23, control .24; .18, control .21; for those cut cephalad .41, control .46; .33, control .34. The difference here as in the comparison of first and second regeneration is in favor of the previously uninjured animal. It is not striking however, and shows that regeneration in either of the two cases presented by the two halves of this set, is almost the same as the first regeneration from the same level.

4. *Level of Injury.* — The rates of regeneration of tadpoles with 7, 10, and 13 mm. of tail removed were compared. From their simple rates it was quite evident that the rate of regeneration in the tail is directly influenced by the amount of tail removed. This is in direct accord with the work done by Spallanzani, who found the whole leg of a salamander to regenerate as soon as a part of it, and the more recent work of Morgan<sup>1</sup> on the tail of *Diemyctylus* in which he states, "the nearer the cut to the outer end the slower the rate of regeneration." However, in order to state this change in rate more concisely, the rate of regeneration was divided by the amount of tail removed and a "proportional rate" obtained. From this proportional rate it was found that the rate of regeneration varies not only directly but *proportionally with the distance the cut is removed from the tip of the tail.*

This point of proportional regeneration is now being worked up in detail in connection with the influence of age.

<sup>1</sup> *Jour. Ex. Zool.*, Vol. III., No. IV., 1906.

Two sets of tadpoles of different ages were used so the data given in the table below are divided into two parts.

Level of Cut in mm.	Rate of Reg.	Prop. Rate.
7	.24	.034
10	.34	.034
13	.43	.033
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7	.19	.027
10	.26	.026
13	.34	.026

#### SUMMARY.

1. The rate of regeneration of a tadpole tail varies inversely as the age of the tadpole.
2. In successive regenerations from a given level the first and second regenerations are approximately equal.
3. Regeneration from recently regenerated tissue, and from old tissue of a tadpole tail that has been regenerating at a level nearer the tip of the tail, is almost the same as first regeneration from the same level.
4. The rate of regeneration in the tail of tadpoles is directly proportional to the distance of the level of the cut from the tip of the tail.